

AMERICAN NATIONAL STANDARD Z136.1 - 2000

Table 5b
Maximum Permissible Exposure (MPE) for Extended-Source Ocular Exposure
to a Laser Beam for Long Exposure Durations[†]

Wavelength (μm)	Exposure Duration, t (s)	MPE		Notes
		($\text{J} \cdot \text{cm}^{-2}$) except as noted	($\text{W} \cdot \text{cm}^{-2}$) except as noted	
Visible				
0.400 to 0.700	10^{-13} to 10^{-11}	$1.5 C_E \times 10^{-8}$		(See Tables 8 and 9 for limiting apertures)
0.400 to 0.700	10^{-11} to 10^{-9}	$2.7 C_E t^{0.75}$		
0.400 to 0.700	10^{-9} to 18×10^{-6}	$5.0 C_E \times 10^{-7}$		
0.400 to 0.700	18×10^{-6} to 0.7	$1.8 C_E t^{0.75} \times 10^{-3}$		
<i>Dual Limits for 400 - 600 nm visible laser exposure for $t > 0.7$ s</i>				
Photochemical	For $\alpha \leq 11 \text{ mrad}$, the MPE is expressed as irradiance and radiant exposure*			(See Tables 8 and 9 for limiting apertures)
0.400 to 0.600	0.7 to 100	$C_B \times 10^{-2}$		
0.400 to 0.600	100 to 3×10^4		$C_B \times 10^{-4}$	
For $\alpha > 11 \text{ mrad}$, the MPE is expressed as radiance and integrated radiance*				
0.400 to 0.600	0.7 to 1×10^4	$100 C_B \text{ J} \cdot \text{cm}^{-2} \cdot \text{sr}^{-1}$		(See Table 8 for limiting cone angle γ)
0.400 to 0.600	1×10^4 to 3×10^4		$C_B \times 10^{-2} \text{ W} \cdot \text{cm}^{-2} \cdot \text{sr}^{-1}$	
<i>and</i>				
Thermal				
0.400 to 0.700	0.7 to T_2	$1.8 C_E t^{0.75} \times 10^{-3}$		
0.400 to 0.700	T_2 to 3×10^4		$1.8 C_E T_2^{-0.25} \times 10^{-3}$	
Near Infrared				
0.700 to 1.050	10^{-13} to 10^{-11}	$1.5 C_A C_E \times 10^{-8}$		(See Tables 8 and 9 for limiting apertures)
0.700 to 1.050	10^{-11} to 10^{-9}	$2.7 C_A C_E t^{0.75}$		
0.700 to 1.050	10^{-9} to 18×10^{-6}	$5.0 C_A C_E \times 10^{-7}$		
0.700 to 1.050	18×10^{-6} to T_2	$1.8 C_A C_E t^{0.75} \times 10^{-3}$		
0.700 to 1.050	T_2 to 3×10^4		$1.8 C_A C_E T_2^{-0.25} \times 10^{-3}$	
1.050 to 1.400	10^{-13} to 10^{-11}	$1.5 C_C C_E \times 10^{-7}$		
1.050 to 1.400	10^{-11} to 10^{-9}	$27.0 C_C C_E t^{0.75}$		
1.050 to 1.400	10^{-9} to 50×10^{-6}	$5.0 C_C C_E \times 10^{-6}$		
1.050 to 1.400	50×10^{-6} to T_2	$9.0 C_C C_E t^{0.75} \times 10^{-3}$		
1.050 to 1.400	T_2 to 3×10^4		$9.0 C_C C_E T_2^{-0.25} \times 10^{-3}$	

[†]See Table 6 and Figures 8, 9 and 11 for correction factors C_A , C_B , C_C , C_E , C_P , and time T_2 .

*For sources subtending an angle greater than 11 mrad, the limit may also be expressed as an integrated radiance $L_p = 100 C_B \text{ J} \cdot \text{cm}^{-2} \cdot \text{sr}^{-1}$ for $0.7 \text{ s} \leq t < 10^4 \text{ s}$ and $L_e = C_B \times 10^{-3} \text{ W} \cdot \text{cm}^{-2} \cdot \text{sr}^{-1}$ for $t \geq 10^4 \text{ s}$ as measured through a limiting cone angle γ . These correspond to values of $\text{J} \cdot \text{cm}^{-2}$ for $10 \text{ s} \leq t < 100 \text{ s}$ and $\text{W} \cdot \text{cm}^{-2}$ for $t \geq 100 \text{ s}$ as measured through a limiting cone angle γ .

$\gamma = 11 \text{ mrad}$ for $0.7 \text{ s} \leq t < 100 \text{ s}$,

$\gamma = 1.1 \times t^{0.3} \text{ mrad}$ for $100 \text{ s} \leq t < 10^4 \text{ s}$

$\gamma = 110 \text{ mrad}$ for $10^4 \text{ s} \leq t < 3 \times 10^4 \text{ s}$

See Figure 3 for γ and Appendix B7.2 for examples.

Notes:

- For repeated (pulsed) exposures, see Section 8.2.3.
- The wavelength region λ_1 to λ_2 means $\lambda_1 \leq \lambda < \lambda_2$, e.g., 1.180 to 1.302 μm means $1.180 \leq \lambda < 1.302 \mu\text{m}$.
- Dual Limit Application: In the Dual Limit wavelength region (0.400 to 0.600 μm), the exposure limit is the lower value of the determined photochemical and thermal exposure limit.